Evaluation of Silages of Potato, Sweet Potato and Turnip with Rice Straw or Wheat Straw with or without Urea and Studies the Effect of Rations Containing Its Silages on Digestion Coefficients and Rumen Fermentation in Sheep

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Abstract: The objectives of this study were evaluation the silages containing of non-commercial potato tubers, sweet potato roots, and turnip roots. Silages were making manually in jars in the 1st experiment with mixing cutting tubers or roots with rice straw or wheat straw with urea additives at levels0, 0.5% and 1% for determining chemical composition and fermentation characteristics of silages. In the 2nd experiment, silages were making manually in bags with mixing cutting tubers or roots with rice straw + 2% molasses with 0 or 0.5% urea for evaluating seven rations by rams as follows: Ration A 100% of CP requirements according to NRC (1985) from concentrate feed mixture (CFM) + rice straw *ad lib*. Rations B, C and D were 60% of CP requirements from CFM + silages of potato, sweet potato and turnip, respectively. Rations E, F and G were 60% of CP requirements from CFM + silages of potato, sweet potato and turnip containing 0.5% urea, respectively. Silages were fed *ad lib.* Digestion coefficients and rumen fermentation were conducted to evaluate rations A, B, C, D, E, F and G using 21 local rams (3 in each) averaged weight 49 kg. Results explained that DM% of potato tubers, sweet potato and turnip roots were 18.18, 20.08 and 7.50%, respectively and CP% was 13.31, 10.46 and 13.46%, respectively. DM of potato silage ranged from 34.31 to 35.68%, sweet potato silage ranged from 34.39 to 35.73% and turnip silage ranged from 31.57 to 37.71%. CP in silage with urea was higher than silage without urea. Silage fermentation characteristics explained that pH ranged from 3.80 to 4.20, Ammonia-N% of total N ranged from 9.61 to 16.22%, Acetic acid ranged from 2.36 to 3.52 g/100g DM, Butyric acid ranged from 0.28 to 1.34 g/100g DM and lactic acid ranged from 6.31 to 9.65 g/100g DM. Ammonia-N as g/100g DM was increased with increasing urea levels. The differences of DM intake as % of LBW among all rations containing silages were not significant. Digestion coefficients of DM, OM of ration A was significantly ($P<0.05$) higher than all rations and the differences among other rations containing silages were not significant. Digestion coefficients of DM of rations containing silages ranged from 52.88 to 56.94%, OM ranged from 54.69 to 59.03% and CP ranged from 58.61 to 64.8%. TDN of control was 60.49 and other rations containing silages ranged from 51.61 to 55.83%. DCP of control was 8.08 and other rations ranged from 7.79 to 9.58%. Digestion coefficients and nutritive values were not affected with urea additives. Ruminal parameters indicated that the differences of ruminal pH among all rations were not significant at 4h post feeding. The differences of NH_3-N and Total VFA's among rations B, C and D were not significant and the differences among rations E, F and G were not significant at 2 and 4h post feeding**.** The NH_3-N and VFA's of rations containing silages with urea was significantly ($P<0.05$) higher than control and rations containing silages without urea. The differences of Microbial protein among all rations were not significant except ration B was lower than other rations.

***Keywords:** Potato, sweet potato, turnip, silage, urea, rams, digestion coefficients, ruminal parameters*

INTRODUCTION

The shortage in animal local feed sources and high price of traditionally feeding especially concentrates are limiting animal production in Egypt. Therefore, the untraditionally feed is necessary for animal feeding. The crop residues such as corn stover, wheat straw and rice straw are utilizing in animal feeding with or without treatments. On the other side, by-products of roots and tubers could be utilizing in animal nutrition. The main problem in these products is produce in short time during harvesting of the crop. Moreover, these by-products had a high content of moisture. Leonel *et al.* (2017) found that DM of Potato tubers ranged from 11.89 to 21.83%, Samy *et al.* (2014) found that the DM of different cultivars of sweet potato roots ranged from 17.0 to 26.5% and Penno *et al.* (1996) mentioned that DM of turnip roots ranged from 8.6 to 8.7%. Therefore, these tubers and roots could be ensiled with dry crop residues such as rice straw and wheat straw for produce optimum DM in silages. Sadri *et al.* (2018) found that DM of silage contained potato and wheat straw was 32.2%, Mutavhatsindi *et al.* (2018) found that DM of silage contained Potato hash and wheat bran was 35.2%, Babaeinasab *et al*. (2015) found that DM of silage contained Potato+wheat straw was 32.2% and Hart and Horn (1987) mentioned that DM of silage containing turnip and wheat straw was 33.2%. Recently studies explained that silage fermentation characteristics of mixing tubers with crop residues lie in the good quality silage (Sadri *et al.,* 2018; Rui-rui *et al.*, 2018; Mutavhatsindi *et al.,* 2018; Babaeinasab *et al*., 2015). HaiYan *et al.* (1998) noticed that no significant differences in ammonia-N concentration among different silages of turnip containing 6, 12 and 18% rice straw. Adding molasses improved the ensiling fermentation of potato-wheat straw silage (Babaeinasab *et al*., 2015). Hart and Horn (1987) found that pH and NH_3-Nwere increased and lactic acid was decreased with increasing levels of wheat straw in turnip ensiled with straw while the acetic and butyric acids not affected. Ruiz *et al.* (1981) found that acetic, butyric and lactic acids were fluctuated with different levels of

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urea in sweet potato silage treated with urea levels 0, 0.4, 0.8 and 1.2%. The silages containing tubers and roots were good palatability by ruminants (Sadri *et al*., 2018; Nkosi *et al*., 2010 with sheep and Aibibula, *et al.*, 2007; Nelson *et al.*, 2000 with cattle). A little information was found on digestion coefficient and rumen fermentation of rations containing silages of potato tubers or sweet potato and turnip roots. Sadri *et al.* (2018) found that digestion coefficients of DM and CP were 67.7 and 67.0% of ration containing 30% potato-wheat straw silage + CFM + alfalfa by sheep. Nkosi *et al*. (2010) found that digestion coefficients of DM and CP were 49.30 and 40.40% of silage containing 80% potato hash + 20% hay by sheep. Hart and Horn (1987) found that OM digestibility was 63.0%, ruminal pH was 6.72 and ruminal total VFA was 82.6 mmol/L of sheep fed silage containing 72.3% turnip and 27.7% wheat straw.

However, there is limited information on ensiling these tubers and roots with or without additives. So, the aim of this study was evaluation the silages containing non-commercial potato tubers, sweet potato roots, and turnip roots with rice straw and wheat straw with or without urea additives and effect of rations containing its silages on digestion coefficients and rumen fermentation in sheep.

MATERIALS AND METHODS

This study was carried out at Animal Production Research Institute, Agricultural Research Center, Egypt. Two experiments were conducted:

1st experiment for making silage in jars:

This experiment was carried out at Animal Nutrition Unite of Ismailia Research Station (Ismailia governorate) (Animal Production Research Institute). Potato tubers, sweet potato roots and turnip roots were obtained from Ismailia market then cutting by using knives and mixed with chopped rice straw or wheat straw, then mixed with urea at levels 0, 0.5 and 1% on fresh basis in 18 treatments (9 with rice straw and 9 with wheat straw). The silage contents were calculated to give silage containing 35% DM. Every mixture put in jar capacity 1 kg (three jars in each treatment) with good pressing, and then closes every jar tightly to provide a non aerobic environment. The jars were opened after 45 days for measuring chemical composition and silage fermentation characteristics.

2nd experiment for making silage in bags:

This experiment was carried out at Animal Nutrition Research Department (Animal Production Research Institute). Potato tubers, sweet potato roots and turnip roots were obtained from Aloboor market then cutting by using knives and mixed with chopped rice straw in six mixtures as follows:

1-75% Potato and 25% rice straw + 2% molasses. 2-75% sweet potato and 25% rice straw + 2% molasses. 3-75% turnip and 25% rice straw + 2% molasses. 4-75% Potato and 25% rice straw + 2% molasses + 0.5% urea. 5-75% sweet potato and 25% rice straw + 2% molasses + 0.5% urea. 6-75% turnip and 25% rice straw + 2% molasses + 0.5% urea, then every mixture was putted into a plastic bag capacity 250 kg with a good pressing and still 45 days before opening. These silages were evaluated.

Seven experimental rations were evaluated by using rams as follows:

Ration A: 100% of CP requirements according to NRC (1985) from Concentrate Feed Mixture (CFM) + Rice straw *ad lib*.

Ration B: 60% of CP requirements according to NRC (1985) from CFM + silage of potato (1)

Ration C: 60% of CP requirements according to NRC (1985) from CFM + silage of sweet potato (2)

Ration D: 60% of CP requirements according to NRC (1985) from CFM + silage of turnip (3)

Ration E: 60% of CP requirements according to NRC (1985) from CFM + silage of potato contained 0.5% urea (4)

Ration F: 60% of CP requirements according to NRC (1985) from CFM + silage of sweet potato contained 0.5% urea (5)

Ration G: 60% of CP requirements according to NRC (1985) from CFM + silage of turnip contained 0.5% urea (6)

Digestibility trials were conducted to evaluate the rations A, B, C, D, E, F and G using 21 Local rams (3 rams in each) averaged weight 49 kg. Rams were individually housed in metabolic cages. Preliminary period was 21 days and collection period were 5 days, followed 3 days for rumen fermentation studies. Concentrate feed mixture (CFM) was daily offered to the animals in two equal portions at 8 am and 4 pm. The silages were weighed and offered *ad lib*. Residual were collected and weighed daily. Drinking water was available all time.

Composite samples of CFM, rice straw, wheat straw, potato, sweet potato, turnip and silages of experimental jars and bags were dried in oven at 60ºC for 24 h. Samples of daily feces were collected and dried in oven at 60ºC for 24 h. Composite samples of feeds and feces were milling to pass through 1 mm screen and stored for chemical analysis. Chemical composition of representative samples was determined according to AOAC (1995) procedures.

Analytical samples were collected at the time when experimental jars and plastic bags were opened for determine silage characteristics. All samples were prepared for analysis by extracting homogenized 50 gm (wet material) with 500 ml distilled water for 10 minutes in a warming blender (Waldo and Schultz, 1956) the homogenate was filtered through four-layer cheese cloth. The filtrate was used to determine pH directly using a digital pH meter. Ammonia nitrogen (NH_3-N) was determined according to AOAC (2016). The acetic, butyric and lactic acids were determined by the distillation method as reported by Research Institute for cattle feeding at Hoorn, Holland (1961) as described by Nowar (1969).

Rumen fluid samples were taken from rams using a stomach tube at 0 time (before feeding), 2 h and 4h post feeding. These samples were filtered through three layers of surgical gauze without squeezing. Ruminal pH was immediately estimated by digital pH meter. Rumen ammonia-N was determined according to Conway (1957). Total volatile fatty acids (TVFAs) were measured by the steam distillation method as described by Warner (1964). Microbial protein was determined by the sodium tungstate method according to Shultz and Shultz (1970).

All data were subjected to analysis was performed using the General linear Models (GLM) procedure of the SPSS 24. Mean differences were compared using Duncan multiple range test (Duncan, 1955). Data were analyzed using the following mathematical model:

$Yij = \mu + Ti + eij$

Yij = Individual observation, μ = overall mean,

Ti= effect of the i^{th} treatments and

eij = Random residual error

RESULTS AND DISCUSSION

Chemical analysis of ingredients is presented in Table (1). DM contents of potato (18.18%) and Sweet potato (20.08%) were higher than turnip (7.50%). OM of potato (81.85%) and sweet potato (79.58%) were lower than turnip (88.53%). CP of potato (13.31%) and turnip (13.46%) was higher than sweet potato (10.46%). DM% of potato tubers lie within the range values obtained by Leonel *et al.* (2017). The DM% of sweet potato roots lie within the range values obtained by Samy *et al.* (2014). The CP% of potato was nearly with CP obtained by Charmley *et al.* (2006). The CP% in sweet potato roots lie within the range values obtained by Samy *et al.* (2014). The CP% of turnip roots lie within the data obtained by Ali *et al.* (2014), Altinok and Karakaya (2003) and Jacobs *et al*. (2001).

Table (1): Chemical composition of potato tubers, sweet potato roots turnip roots, CFM, rice straw and wheat straw On DM basis (%)

Items	Potato tubers	Sweet potato roots	Turnip roots	CFM*	RS	WS
DM	18.18	20.08	7.50	92.21	89.36	90.70
OM	81.85	79.58	88.53	91.65	86.25	87.21
CP	13.31	10.46	13.46	16.81	3.25	3.42
EE	1.10	0.80	0.93	3.80	1.86	2.10
CF	7.10	7.02	14.67	12.38	38.23	35.39
NFE	60.34	61.30	59.47	58.66	42.91	46.30
Ash	18.15	20.42	11.47	8.35	13.75	12.79

CFM: concentrate feed mixture, RS: rice straw, WS: wheat straw

* CFM was formulated from 24% Sunflower meal, 15% wheat bran, 55% yellow corn, 3% molasses, 2% lime stone and 1% common salt

Chemical analysis of silages of Potato, Sweet potato and turnip with RS or WS with or without urea additives ensiling in jars in experiment1 is presented in Table (2). DM of potato silage ranged from 34.31 to 35.68%, DM of sweet potato silage ranged from 34.39 to 35.73% and DM of turnip silage ranged from 31.57 to 37.71%. The chemical composition explained that OM% of potato silage and sweet potato silage was lower than OM% in turnip silage with or without urea. The CP% of potato silage was higher than sweet potato silage, and CP% of sweet potato silage was higher than turnip silage with or without urea. As expected, the CP% in all silages was increased with increasing urea levels. However, the chemical composition values of silages with RS or WS was nearly similar.

Chemical composition of silages in experiment 2 of potato, sweet potato and turnip with RS in plastic bags which fed by rams as shown in Table (4) explained that DM content of potato silage, sweet potato silage and turnip silage was 36.13, 38.14 and 32.34%, respectively without urea additives and 36.39, 37.44 and 30.19%, respectively with 0.5% urea. The OM content of potato silage and sweet potato silage was lower than turnip silage with or without urea. The CP content of potato silage and sweet potato silage was slightly higher than turnip silage without urea. The CP content of silages with 0.5% urea was higher than silages without urea. The EE and NFE of potato silage and sweet potato silage were lower than turnip silage while CF and ash of turnip silage was lower than potato silage and sweet potato silage with or without urea.

Fermentation characteristics of silages in jars as presented in Table (3) explained that pH values ranged from 3.8 to 4.2 of all treatments with no significant differences among all silages. Ammonia-N values as g/100g DM in silages were increased with increasing urea levels. Ammonia-N in potato silage with rice straw significantly ($P<0.05$) increased from 0.23 without urea to 0.32 g/100g DM with 1% urea. Ammonia-N in sweet potato silage significantly ($P<0.05$) increased from 0.21 without urea to 0.32 g/100g DM with 1% urea. Ammonia-N in turnip silage significantly ($P<0.05$) increased from 0.20 without urea to 0.32 g/100g DM with 1% urea. Ammonia-N % of total N of sweet potato silage and turnip silage with rice straw with 1% urea was significantly ($P<0.05$) higher than all silages. Acetic acid of sweet potato was significantly ($P<0.05$) higher than potato and turnip silages without urea while turnip silage was significantly ($P<0.05$) higher than potato and sweet potato silages with 1% urea. Butyric acid and lactic acid of turnip silages with rice straw without or with 1% urea was significantly ($P<0.05$) higher than potato and sweet potato silages. The effect of urea additives on lactic acid was not clear.

Fermentation characteristics of silages in plastic bags for rams feeding as shown in Table (4) explained that pH values in silages of potato, sweet potato and turnip were nearly similar. The pH values with urea were slightly higher than without urea. Ammonia-N (% of total N) of potato silage with or without urea was significantly (P<0.05) higher than all silages. Butyric acid in turnip silage with 0.5 % urea was significantly (P<0.05) higher than all silages. Acetic acid and lactic acid in turnip silage with or without urea were significantly (P<0.05) higher than all silages.

Table (2): Chemical composition (% on DM basis) of experimental silages of potato, sweet potato and turnip with rice straw or wheat straw with or without urea ensiling in jars

Items	Potato silage	Sweet potato silage	Turnip silage	Potato silage	Sweet potato silage	Turnip silage	Potato silage	Sweet potato silage	Turnip silage
	Without urea			**With 0.5 % urea**			**With 1 % urea**		
With rice straw									
DM	34.31	34.94	33.62	35.11	35.04	32.40	35.12	35.23	31.57
OM	83.83	82.41	88.94	83.91	82.17	88.22	83.63	81.98	87.59
CP	11.66	10.02	9.52	13.04	11.40	10.90	14.44	12.80	12.30
EE	1.25	1.37	3.87	1.35	1.31	3.40	1.48	1.70	3.17
CF	30.55	31.25	24.06	28.48	27.87	25.03	29.40	28.40	26.61
NFE	40.37	39.77	51.49	41.04	41.59	48.89	38.31	39.08	45.54
Ash	16.17	17.59	11.06	16.09	17.83	11.78	16.37	18.02	12.41
With wheat straw									
DM	34.52	34.63	37.71	34.86	34.39	34.68	35.68	35.73	33.06
OM	84.43	82.75	89.48	84.29	82.33	89.49	84.38	82.72	88.67
CP	11.33	10.52	9.78	12.70	11.90	11.18	14.10	13.30	12.58
EE	1.22	1.40	2.84	1.09	1.74	2.45	1.74	1.96	3.63
CF	28.04	29.25	25.54	24.42	23.85	22.66	28.34	29.85	26.92
NFE	43.84	41.58	51.32	46.08	44.84	53.20	40.20	37.61	45.54
Ash	15.57	17.25	10.52	15.71	17.67	10.51	15.63	17.28	11.33

Table (3): Silage fermentation characteristics of different silages with rice straw or wheat straw with or without urea in jars

Items	Potato silage	Sweet potato silage	Turnip silage	Potato silage	Sweet potato silage	Turnip silage	Potato silage	Sweet potato silage	Turnip silage
	Without urea			**With 0.5 % urea**			**With 1 % urea**		
With rice straw									
pH value	4.10^{a} ± 0.06	3.80^{b} ± 0.04	4.13^{a} ± 0.08	4.17^{a} ± 0.02	4.20^{a} ± 0.06	4.00^{b} ± 0.04	4.20^{a} ± 0.06	4.20^{a} ± 0.06	4.10^{a} ± 0.06
Ammonia-N (g/100gDM)	0.23^{a} ± 0.01	0.21^{b} ± 0.01	0.20^{b} ± 0.01	0.29^{a} ± 0.01	0.24^{b} ± 0.01	0.21^{c} ± 0.01	0.32^{a} ± 0.01	0.32^{a} ± 0.01	0.32^{a} ± 0.01
Ammonia-N (% of total N)	12.25^{b} ± 0.01	13.00^{a} ± 0.01	13.12^{a} ± 0.01	13.76^{a} ± 0.01	13.14^{a} ± 0.01	11.89^{b} ± 0.01	13.80^{c} ± 0.01	15.52^{b} ± 0.01	16.22^{a} ± 0.01
Acetic acid (g/100g DM)	2.83^{c} ± 0.01	3.22^{a} ± 0.01	3.16^{b} ± 0.01	2.49^{b} ± 0.05	3.05^{a} ± 0.01	3.22^{a} ± 0.01	2.83^{a} ± 0.01	2.47^{c} ± 0.01	3.07^{a} ± 0.01
Butyric acid (g/100g DM)	0.45^{b} ± 0.01	0.50^{b} ± 0.01	0.99^{a} ± 0.01	0.69^{a} ± 0.03	0.34^{c} ± 0.01	0.51^{b} ± 0.01	0.28^{b} ± 0.01	0.64^{a} ± 0.01	0.80^{a} ± 0.01
Lactic acid (g/100g DM)	9.17^{b} ± 0.01	9.05^{b} ± 0.01	9.65^{a} ± 0.01	6.61^{c} ± 0.01	7.06^{b} ± 0.01	7.30^{a} ± 0.01	6.82^{b} ± 0.01	6.31^{c} ± 0.01	8.83^{a} ± 0.01
With wheat straw									
pH value	3.80^{a} ± 0.06	3.90^{a} ± 0.01	3.85^{a} ± 0.02	3.85^{a} ± 0.08	3.84^{a} ± 0.03	4.00^{a} ± 0.06	4.00^{a} ± 0.06	4.01^{a} ± 0.05	4.01^{a} ± 0.05
Ammonia-N (g/100g DM)	0.26^{a} ± 0.01	0.16^{c} ± 0.01	0.21^{b} ± 0.01	0.26^{a} ± 0.01	0.26^{a} ± 0.01	0.24^{b} ± 0.01	0.31^{a} ± 0.01	0.31^{a} ± 0.01	0.25^{b} ± 0.01
Ammonia-N (% of total N)	14.32^{a} ± 0.02	9.61^{c} ± 0.01	13.29^{b} ± 0.02	12.65^{b} ± 0.01	13.68^{a} ± 0.01	13.54^{a} ± 0.01	13.91^{b} ± 0.01	14.73^{a} ± 0.01	12.62^{c} ± 0.01
Acetic acid (g/100g DM)	2.63^{b} ± 0.01	3.13^{a} ± 0.04	2.74^{b} ± 0.03	2.99^{b} ± 0.05	3.43^{a} ± 0.01	2.97^{b} ± 0.02	2.73^{b} ± 0.03	3.09^{a} ± 0.02	3.52^{a} ± 0.03
Butyric acid (g/100g DM)	0.39^{c} ± 0.01	1.26^{a} ± 0.01	1.14^{b} ± 0.01	1.34^{a} ± 0.03	1.07^{b} ± 0.01	0.41^{c} ± 0.01	1.00^{a} ± 0.01	0.50^{c} ± 0.01	0.70^{b} ± 0.01
Lactic acid (g/100g DM)	8.33^{b} ± 0.01	9.30^{a} ± 0.01	6.85^{c} ± 0.01	7.70^{a} ± 0.03	6.97^{b} ± 0.01	6.80^{b} ± 0.01	7.79^{a} ± 0.01	6.49^{b} ± 0.01	7.55^{a} ± 0.01

^{a,b,c} means in the same row with different superscripts are significantly different (P < 0.05)

Table (4): Chemical composition and silage fermentation characteristics of silages of potato, sweet potato and turnip with rice straw with and without urea fed by rams

Items	Potato silage	Sweet potato silage	Turnip silage	Potato silage	Sweet potato silage	Turnip silage
	Without urea			With 0.5 % urea		
Chemical composition (%) on DM basis						
DM	36.13	38.14	32.34	36.39	37.44	30.19
OM	84.65	83.88	88.50	84.48	83.31	87.36
CP	10.99	10.39	9.71	12.37	11.81	11.13
EE	1.94	1.84	3.09	1.59	1.68	2.65
CF	31.44	29.23	28.66	30.78	29.81	28.62
NFE	40.28	42.42	47.04	39.74	40.01	44.96
Ash	15.35	16.12	11.50	15.52	16.69	12.64
Silage fermentation characteristics						
pH value	$3.94^{a}\pm0.01$	$3.98^{a}\pm0.01$	$3.86^{b}\pm0.01$	$4.20^{a}\pm0.06$	$4.10^{a}\pm0.06$	$4.20^{a}\pm0.06$
Ammonia-N (% of total N)	$14.10^{a}\pm0.01$	$12.37^{c}\pm0.01$	$13.37^{b}\pm0.01$	$13.22^{a}\pm0.01$	$7.92^{c}\pm0.01$	$12.50^{b}\pm0.01$
Acetic acid (g/100g DM)	$2.89^{b}\pm0.01$	$2.36^{c}\pm0.01$	$3.07^{a}\pm0.01$	$2.66^{b}\pm0.01$	$2.66^{b}\pm0.01$	$3.50^{a}\pm0.01$
Butyric acid (g/100g DM)	$0.93^{a}\pm0.01$	$0.05^{c}\pm0.01$	$0.27^{b}\pm0.03$	$1.16^{b}\pm0.01$	$0.36^{c}\pm0.01$	$1.67^{a}\pm0.01$
Lactic acid (g/100g DM)	$7.95^{a}\pm0.01$	$6.26^{b}\pm0.01$	$8.20^{a}\pm0.01$	$6.47^{b}\pm0.01$	$6.64^{b}\pm0.01$	$8.10^{a}\pm0.01$

^{a,b,c} means in the same row with different superscripts are significantly different ($P < 0.05$)

The DM percent of silages in this study was nearly similar with Mutavhatsindi *et al.* (2018) (35.2%), Sadri *et al.* (2018) (32.2%), Babaeinasab *et al*. (2015) (32.2-36.0%), Hough *et al.* (1994) (38.2%) and Hart and Horn (1987) (32.2%). However, the chemical composition of silage is affected with difference of silage components. Pen *et al*. (2006) found that CP was 14.40% in silage containing potato by-products. Hadgu *et al.* (2015) found that CP in sweet potato silage ranged from 10.9 to 16.2%. Hart and Horn (1987) found that CP ranged from 7.7 to 10.5% in turnip-wheat straw silage.

Silage fermentation characteristics in this study explained that pH as important indicator for silage fermentation quality ranged from 3.80 to 4.20 of potato, sweet potato and turnip silages. These values agree with those obtained by Rui-rui *et al.* (2018), Sugimoto *et al.* (2010), Hough *et al.* (1994), Hadgu *et al.* (2015), Babaeinasab *et al.* (2015) and Nkosi and Meeske (2010). Sugimoto *et al.* (2007) noticed that pH value of potato pulp silage without urea was less than urea-treated potato pulp silage. Hart and Horn (1987) noticed that pH value of silage containing turnip and wheat straw was lower than that silage containing turnip and ammoniated wheat straw. Generally, good quality silage is containing pH under 4.8 (Alberta Agriculture Food and Rural Development 2004). Ammonia-N in this study ranged from 0.15 to 0.32 g/100g DM. These values agree with those obtained by Kleinschmit and Kung (2006) and Hart and Horn (1987). Ammonia-N% of total N in this study was less than 15% except sweet potato and turnip silages containing RS with 1% urea which was 15.52 and 16.22%. These results agreed with Rigueira *et al.* (2013) who found that ammonia-N ranged from 10 to 20.7 from total N and Nicholson and Macleo (1966) who found that ammonia N in various silages ranged from 11.9 to 16.5% of total N. On the other hand, ammonia-N% of total N in this study was higher than that obtained by Rui-rui *et al.* (2018), Babainasab *et al.* (2015) and Giang *et al.* (2004). However, Kung *et al.* (2018) mentioned that NH_3-N usually less than 15% of total N of silage and Mahanna (1994) mentioned that silages containing 10-15% ammonia-N of total N are considered of good quality silage. Generally, ammonia-N from silage with available energy in the rumen is using by rumen microorganisms for synthesis microbial protein. Acetic acid in silage in this study ranged from 2.36 to 3.52 g/100g DM. These values agree with those obtained by Giang *et al.* (2004) and Hart and Horn (1987) and were higher than that obtained by Rui-rui *et al.* (2018), Nkosi and Meeske (2010) and Okine *et al.* (2007). However, Ruiz *et al.* (1981) mentioned that there are no norms indicating optimum or maximum values of acetic acid in good quality silages. Generally, the effect of high acetic acid concentration on intake of silage remains unclear (Alberta Agriculture Food and Rural Development 2004). Kung *et al.* (2018) explained that acetic acid of silage absorbed from the rumen and can be used for energy source in ruminants. Butyric acid in this study was less than 1% of DM in all silages with rice straw without urea. Similar results were showed by Kung *et al.* (2018) and Nicholson and Macleo (1966). On the other side, Butyric acid in silage with urea was higher than that without urea. The same trend was showed by Ruiz *et al.* (1981) who found that butyric acid production was increased with increasing urea levels in sweet potato silage and Hart and Horn (1987) who found that butyric acid of silage containing turnip and ammoniated wheat straw was higher than silage of turnip and wheat straw without ammonia. Giang *et al.* (2004) found that butyric acid ranged from 0.33 to 0.47 g/kg DM of sweet potato silage while Ruiz *et al.* (1981) found that butyric acid ranged from 1.14 to 3.28% on DM basis of sweet potato silage. Lactic acid in silages of potato, sweet potato and turnip in this study ranged from 6.31 to 9.65 g/100g DM (6.31 to 9.65%). Similar values were found by Mutavhatsindi *et al.* (2018), Okine *et al.* (2005), Abo-Donia *et al.* (2004) and Hart and Horn (1987). However, these values lie within the normal data of good quality silage as reported by Zobell *et al.* (2005) who stated that the high levels of lactic acid concentration between 3 - 14% DM characterize good quality silage. Also, McDonald *et al.* (2010) mentioned that the lactic acid contents generally lie in the range 8-12% of silage DM. The effect of urea on lactic acid was fluctuated. The same trend was showed by Ruiz *et al.* (1981). Generally, lactic acid from silage is converted to propionic acid in the rumen under normal feeding conditions (Kung *et al*., 2018).

The values of DM intake (Table 5) as g/head/day, % of LBW and g/kg $W^{0.75}$ of ration A (control) (containing CFM+ RS) were significantly (P<0.05) higher than all rations (containing CFM + silages). The differences of DM intake as % of LBW and g/kg $W^{0.75}$ among all rations containing silages (B, C, D, E, F and G) were not significant and silages intakes were nearly similar. The differences of DM intake among the rations containing silages with or without urea were not significant. The same trend was showed by Sugimoto *et al*. (2007) who noticed that treating of potato pulp silage with urea did not affect the DM intake. However, Sadri *et al*. (2018) found that the daily intake of DM was not significantly affected by different levels of potato-wheat straw silage in the rations.

Table (5): Intake, digestion coefficients and nutritive values of experimental rations by rams

Items	Ration A	Without urea additives			With 0.5% urea additives		
		Ration B	Ration C	Ration D	Ration E	Ration F	Ration G
DM intake							
CFM, g/h/d	885	538	547	541	532	553	518
RS, g/h/d	411	-	-	-	-	-	-
Silage, g/h/d	-	355	407	341	360	399	308
Total, g/h/d	1296^{a}	893^{c}	954^{b}	882^{c}	892^{c}	952^{b}	826^{d}
Total, % of LBW	2.43^{a}	1.86^{b}	1.97^{b}	1.85^{b}	1.87^{b}	1.96^{b}	1.74^{b}
Total, g/kg $w^{0.75}$	65.72^{a}	48.92^{b}	51.87^{b}	48.61^{b}	49.03^{b}	51.82^{b}	45.55^{b}
Digestion coefficients %							
DM	$62.67^{a} \pm 0.47$	$56.94^{b} \pm 0.25$	$54.09^{b} \pm 0.73$	$53.38^{b} \pm 2.75$	$54.98^{b} \pm 1.11$	$54.45^{b} \pm 0.71$	$52.88^{b} \pm 1.02$
OM	$63.32^{a} \pm 0.47$	$59.03^{b} \pm 0.24$	$54.69^{c} \pm 0.71$	$56.42^{bc} \pm 2.57$	$56.66^{bc} \pm 1.08$	$55.27^{bc} \pm 0.69$	$55.57^{bc} \pm 0.96$
CP	$64.57^{a} \pm 0.46$	$64.48^{a} \pm 0.20$	$60.64^{abc} \pm 0.06$	$55.27^{c} \pm 2.69$	$63.62^{ab} \pm 0.94$	$58.61^{bc} \pm 0.64$	$60.88^{abc} \pm 0.86$
CF	$58.87^{a} \pm 0.51$	$51.62^{b} \pm 0.49$	$51.71^{b} \pm 0.97$	$47.30^{bc} \pm 2.99$	$49.17^{bc} \pm 1.23$	$48.14^{bc} \pm 0.81$	$45.53^{c} \pm 1.16$
EE	$89.10^{a} \pm 0.14$	$86.97^{bc} \pm 0.08$	$88.11^{ab} \pm 0.17$	$87.85^{b} \pm 0.72$	$85.09^{d} \pm 0.42$	$82.79^{e} \pm 0.27$	$86.51^{c} \pm 0.29$
NFE	$63.20^{a} \pm 0.47$	$58.67^{ab} \pm 0.23$	$52.28^{c} \pm 0.70$	$57.80^{ab} \pm 2.51$	$55.84^{b} \pm 1.15$	$55.49^{b} \pm 0.69$	$55.53^{b} \pm 0.97$
Nutritive values %							
TDN	$60.49^{a} \pm 0.43$	$55.83^{b} \pm 0.21$	$51.61^{c} \pm 0.62$	$54.91^{bc} \pm 2.36$	$53.44^{bc} \pm 0.99$	$51.74^{c} \pm 0.62$	$53.73^{bc} \pm 0.88$
DCP	$8.08^{de} \pm 0.06$	$9.37^{a} \pm 0.04$	$8.55^{cd} \pm 0.08$	$7.79^{e} \pm 0.39$	$9.58^{a} \pm 0.16$	$8.62^{cd} \pm 0.10$	$8.99^{bc} \pm 0.13$

^{a,b,c,d} means in the same row with different superscripts are significantly different (P<0.05)

Digestion coefficients of experimental rations as shown in Table (5) explained that digestion coefficients of DM and OM% of ration A (control) were significantly (P<0.05) higher than all rations and the differences among other rations containing silages were not significant. The differences of CP digestibility among rations C, D, E and G were not significant. Also, the differences of CP digestibility among rations A, B, C, E and G were not significant. However, the digestion coefficients of DM of rations containing silages ranged from 52.88 to 56.94%, OM ranged from 54.69 to 59.03% and CP ranged from 58.61 to 64.8%. Similar values were obtained by Nkosi *et al.* (2010) who found that digestion coefficients of DM ranged from 49.30 to 59.31%, OM ranged from 48.95 to 59.51% and CP ranged from 40.4 to 65.3% in the rations containing silage potato hash. Sugimoto *et al.* (2007) found that digestion coefficients of DM, OM and CP were 58.3, 60.1 and 71.90%, respectively of ration containing potato pulp silage while Sugimoto *et al*. (2010) found that digestion coefficients of DM, OM and CP were 63.7, 65.1 and 41.8%, respectively of ration containing potato pulp silage. The CF digestibility of ration A was significantly (P<0.05) higher than other rations while the differences among all rations containing silages were not significant except ration G was significantly

($P<0.05$) lower than rations B and C. The NFE digestibility of ration C was significantly ($P<0.05$) lower than other rations. The differences of NFE digestibility among control and rations B and D were not significant, also the differences among rations B, D, E, F and G were not significant. The effect of urea on digestion coefficients of DM, OM, CP and CF% was not significant. Similar effect was noticed by Sugimoto *et al.* (2007). This result was due probably to the slight difference in dietary CP concentration between the rations contained urea-treated and untreated silages which may be did not affect digestion coefficients. Generally, digestion coefficients are affected by species and age of the animal, chemical composition of feed, level of feeding, preparation of feed, particle size of feed, additives, associative effect of feed components and rate of passage of digesta through the alimentary tract. The TDN in ration A was significantly ($p< 0.05$) higher than all rations containing silages. The TDN of sweet potato silage was significantly ($p< 0.05$) lower than potato and turnip silages while, the TDN of potato and turnip silages was nearly similar. The differences among rations containing silages with or without urea were not significant. The DCP of rations containing potato silage (B and E) was significantly ($p< 0.05$) higher than all rations. Generally, the TDN was calculated from the percentages and digestion coefficients of CP, CF, EE and NFE in the rations, and DCP was calculated from CP percent and its digestibility in the rations, therefore the chemical composition and digestion coefficients of these nutrients in the rations was reflected on nutritive values as TDN and DCP.

Rumen fermentation parameters of rams are presented in Table (6). The maximum pH values were recorded at 0h (before feeding) with all groups, then significantly ($P<0.05$) decreased at 2h then increased at 4h post feeding. The same trend was showed by Sugimoto *et al.* (2007) who found that the maximum ruminal pH was recorded at 0 time then decreased at 2 h post feeding and Osman *et al*. (2007) who found that the maximum ruminal pH was recorded at 0 time then decreased at 2h post feeding then increased at 4h post feeding. The differences of ruminal pH at 2 h post feeding among rations A, B, C and D (without urea) were not significant, also the differences among rations E, F and G (with urea) were not significant. The differences at 4h post feeding of pH among all rations were not significant. Sugimoto *et al.* (2007) noticed that urea-treated did not significantly change the pH in the rumen. Ruminal pH values in all rations ranged from 5.52 to 7.2. These values are lie within the normal pH in the rumen as mentioned by Hungate (1966) who mentioned that the normal pH for normally functioning in the rumen is ranged from 5.5 to 7.3. The lowest values of ruminal NH_3-N were recorded at 0h of all rations, then significantly ($P<0.05$) increased at 2h and 4h post feeding. Sugimoto *et al.* (2008) and Osman *et al.* (2007) noticed that the maximum ruminal NH_3-N concentration was showed at 2h post feeding then decreased. The differences among rations B, C and D (without urea) were not significant. Also, the differences among rations E, F and G (with urea) were not significant at 2 and 4h post feeding. Ruminal NH_3-N of rations containing silages with urea was significantly ($P<0.05$) higher than control and rations containing silages without urea.

Table (6): Rumen fermentation parameters in rumen fluid of rams fed experimental rations with or without urea additives

Rumen parameters	Time	Ration A	Without urea additives			With 0.5% urea additives		
			Ration B	Ration C	Ration D	Ration E	Ration F	Ration G
pH	**0**	6.88^{Ac} ± 0.04	7.09^{Ab} ± 0.02	7.20^{Aa} ± 0.02	7.06^{Ab} ± 0.03	7.08^{Ab} ± 0.04	7.12^{Aab} ± 0.03	7.06^{Ab} ± 0.04
	2	5.93^{Ca} ± 0.04	5.88^{Ca} ± 0.02	5.82^{Ca} ± 0.02	5.83^{Ca} ± 0.03	5.54^{Cb} ± 0.05	5.52^{Cb} ± 0.07	5.59^{Cb} ± 0.05
	4	6.50^{Ba} ± 0.12	6.69^{Ba} ± 0.04	6.75^{Ba} ± 0.12	6.64^{Ba} ± 0.05	6.61^{Ba} ± 0.06	6.55^{Ba} ± 0.06	6.61^{Ba} ± 0.05
Ammonia-N (NH3-N) (mg/100ml)	**0**	26.13^{Ba} ± 1.56	26.60^{Ba} ± 1.88	29.40^{Aa} ± 3.45	30.80^{Ba} ± 3.15	28.93^{Ba} ± 2.57	27.53^{Ba} ± 1.68	31.73^{Ba} ± 2.47
	2	33.60^{Ad} ± 1.25	37.33^{Acd} ± 2.25	38.27^{Abcd} ± 2.57	40.60^{Abc} ± 0.96	41.07^{Aabc} ± 2.25	42.93^{Aab} ± 1.18	45.27^{Aa} ± 0.86
	4	37.33^{Ab} ± 3.00	37.80^{Ab} ± 1.20	35.00^{Ab} ± 2.68	37.80^{ABb} ± 2.48	42.93^{Aa} ± 1.87	42.00^{Aa} ± 2.40	43.40^{Aa} ± 2.37
Total volatile fatty acids (TVFA's) (mEq/100ml)	**0**	7.50^{Ab} ± 0.30	7.00^{Bb} ± 0.37	6.67^{Ab} ± 0.75	6.25^{Bb} ± 0.34	11.13^{Aa} ± 0.41	11.04^{Aa} ± 1.12	10.67^{Aa} ± 0.96
	2	8.35^{Ab} ± 0.33	8.00^{ABb} ± 0.35	7.96^{Ab} ± 0.79	8.13^{ABb} ± 0.61	12.13^{Aa} ± 0.55	12.62^{Aa} ± 0.51	11.50^{Aa} ± 0.43
	4	8.28^{Ab} ± 0.25	8.58^{Aab} ± 0.69	8.92^{Aab} ± 0.89	8.83^{Aab} ± 0.78	12.03^{Aa} ± 1.50	12.27^{Aa} ± 0.65	11.92^{Aab} ± 0.58
MP(g/100ml)	**4**	0.72^{a} ± 0.10	0.33^{b} ± 0.04	0.52^{ab} ± 0.07	0.56^{ab} ± 0.14	0.53^{ab} ± 0.09	0.54^{ab} ± 0.07	0.64^{a} ± 0.09

^{A,B,C} means in the same column with different superscripts are significantly different ($P<0.05$)
^{a,b,c,d} means in the same row with different superscripts are significantly different ($P<0.05$)

The same trend was showed by Sugimoto *et al.* (2007) who found that ruminal NH_3-N was higher in Potato pulp silage with urea than that without urea. Total VFA's concentrations in the rumen liquor at 2h and 4h post feeding was significantly ($P<0.05$) higher than at 0h time of all rations. The increase of VFA's in the rumen after feeding due to the fermentation of feed carbohydrates to VFA's. Moreover, the silage is containing VFA's. Also, lactic acid from silage is converting to propionic acid in the rumen as mentioned by Kung *et al*. (2018). Sugimoto *et al*. (2008) noticed that total VFA concentrations was increased after feeding and ranged from 9 to 11 mmol/dL at 2h post feeding. The differences of total VFA among rations A, B, C and D were not significant and the differences among rations E, F and G were not significant. Total VFA's of rations containing silages with urea was significantly ($P<0.05$) higher than control and rations containing silages without urea. The same trend was noticed by Sugimoto *et al.* (2007). The differences of Microbial protein among all rations were not significant except ration B was lower than other rations. However, the synthesis of rumen microbial protein can be affected by synchronizing of energy releasing by fermentation of carbohydrates and N availabilities from nitrogen sources in the rumen as reported by Harun and Sali (2019) and Pathak (2008).

CONCLUSION

It could be concluded that:

1. Non-commercial tubers and roots such as small and very large, broken and unmarketable of Potato, sweet potato and turnip could be ensiling with crop residues such as rice straw and wheat straw.
2. The suitable silages should be containing about 25% dry crop residues such as rice straw and 75% fresh tubers or roots.
3. The feeding 60% of requirements from concentrate feed mixture (CFM) with silages of potato, sweet potato and turnip mixing with rice straw was suitable and safe rations for feeding sheep.
4. The use of urea as a silage additive is requiring more studies.
5. Further studies are recommended to evaluate silages of tuber and roots and its by- products on animal performance and its economical return.

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تقييم سيلاج البطاطس والبطاطا واللفت مع قش الأرز أو تبن القمح مع أو بدون اليوريا ودراسة تأثير العلائق المحتوية على السيلاج على معاملات الهضم وتخمرات الكرش في الأغنام

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أجريت هذه الدراسة بهدف تقييم سيلاج درنات البطاطس وجذور البطاطا وجذور اللفت الغير تجارية. تم عمل السيلاج في التجربة الأولى يدويًا في برطمانات وفيها تم تقطيع الدرنات أو الجذور ثم تم خلط قطع الدرنات أو الجذور مع قش الأرز أو تبن القمح المقطع مع إضافة اليوريا بمستويات صفر و 0,5 و 1٪ وتم تعبئة كل مخلوط في برطمان وكبسه جيدا وتغطيته بإحكام وبعد 45 يوم تم فتح البرطمانات لإجراء التحليل الكيميائي وقياسات جودة تخمر السيلاج. في التجربة الثانية تم تصنيع السيلاج يدويًا في أكياس وفيها تم تقطيع الدرنات أو الجذور ثم تم خلط قطع الدرنات أو الجذور مع قش الأرز + 2٪ مولاس مع صفر أو 0,5٪ يوريا وتم إجراء التحليل الكيميائي وقياسات جودة تخمر السيلاج كما تم تقييم سبعة علائق تجريبية بواسطة الكباش على النحو التالي: العليقة أ : 100٪ من متطلبات البروتين الخام وفقًا لـ NRC (1985) من خليط الأعلاف المركزة + قش الأرز وكانت العلائق ب، ج، د تحتوى على 60٪ من متطلبات البروتين الخام من العلف المركز + سيلاج البطاطس أو البطاطا أو اللفت وكانت العلائق س، ص، ع تحتوى على 60٪ من متطلبات البروتين الخام من العلف المركز + سيلاج البطاطس أو البطاطا أو اللفت والمضاف لها 0,5٪ يوريا. وقد تم تغذية السيلاج للشبع. وقد أجريت تجارب للهضم ودراسات تخمرات الكرش لتقييم العلائق التجريبية (أ، ب، ج، د، س، ص، ع) باستخدام 21 كبشاً (3 في كل منها) بمتوسط وزن 49 كجم. أوضحت النتائج أن نسبة المادة الجافة لدرنات البطاطس وجذور البطاطا وجذور اللفت كانت 18,18 و 20,08 و 7,50٪ على التوالي و نسبة البروتين الخام كانت 13,31 و 10,46 و 13,46٪ على التوالي. تراوحت نسبة المادة الجافة لسيلاج البطاطس من 34,31 إلى 35,68٪، وتراوحت في سيلاج البطاطا من 34,39 إلى 35,73٪ وتراوحت في سيلاج اللفت من 31,57 إلى 37,71٪ وكانت نسبة البروتين الخام في السيلاج مع اليوريا أعلى من السيلاج بدون اليوريا. أوضحت قياسات جودة تخمر السيلاج أن درجة الحموضة تراوحت من 3,80 إلى 4,20 ، وتراوحت نسبة الأمونيا - نيتروجين (٪ من إجمالي النيتروجين الكلى) من 9,61 إلى 16,22٪، وتراوحت قيم حامض الخليك من 2,36 إلى 3,52 جم/100 جم مادة جافة، وتراوحت قيم حامض البيوتريك من 0,28 إلى 1,34 جم/100 جم مادة جافة و تراوحت قيم حامض اللاكتيك من 6,31 إلى 9,65 جم/100 جم مادة جافة. زادت قيم الأمونيا - نيتروجين (جم/100 جم مادة جافة) مع زيادة مستويات اليوريا في السيلاج. لم تكن الاختلافات في المادة الجافة المأكولة كنسبة مئوية من وزن الجسم الحي معنوية بين جميع العلائق التي تحتوي على السيلاج. كانت معاملات الهضم للمادة الجافة و المادة العضوية للعليقة أ مرتفعه معنويا عن جميع العلائق ولم تكن الاختلافات بين العلائق الأخرى المحتوية على السيلاج معنوية. وقد تراوحت معاملات الهضم للمادة الجافة للعلائق التي تحتوي على السيلاج من 52,88 إلى 56,94٪، المادة العضوية تراوحت بين 54,69 إلى 59,03٪ والبروتين الخام من 58,61 إلى 64,8٪. كانت قيم المركبات الكلية المهضومة لعليقة المقارنة 60,49٪ وتراوحت القيم في العلائق التجريبية الأخرى التي تحتوي على السيلاج من 51,61 إلى 55,83٪. كانت قيم البروتين الخام المهضوم لعليقة المقارنة 8,08٪ وتراوحت قيم العلائق التجريبية الأخرى من 7,79 إلى 9,58٪. وعموما لم تتأثر معاملات الهضم والقيم الغذائية بإضافة اليوريا. وقد أشارت دراسات الكرش إلى أن الفروق في رقم الحموضة بين جميع العلائق لم تكن معنوية عند الساعة 4 بعد التغذية. لم تكن الاختلافات بين أمونيا الكرش أو نسبة الأحماض الدهنية الطيارة في سائل الكرش بين العلائق التجريبية ب و ج و د معنوية وكذلك الاختلافات بين العلائق س و ص و ع لم تكن معنوية عند الساعة 2 و 4 بعد التغذية. وعموما كانت قيم أمونيا الكرش ونسبة الأحماض الدهنية الطيارة في سائل الكرش في العلائق التي تحتوي على سيلاج مع اليوريا أعلى معنويا من عليقة المقارنة وكذلك العلائق التي تحتوي على سيلاج بدون يوريا.كما لم تكن الاختلافات في البروتين الميكروبي معنوية بين جميع العلائق إلا أن العليقة ب كانت منخفضة نسبيا عن العلائق الأخرى. ومن هذه النتائج نستخلص انه يمكن عمل سيلاج جيد من درنات البطاطس وجذور البطاطا وجذور اللفت الغير تجارية واستخدامها في تغذية الأغنام.